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(34) Title: PROCESS FOR THE PREPARATION OF N-ACETYL NEURAMINIC ACID DERIVATIVES		
(57) Abstract		
A method for the preparation of 5-acetamido-4-amino-2,3,4,5-tetraoxy-D-glycero-D-galacto-hepta-2-enopyranosonic acid is described.		

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**PROCESS FOR THE PREPARATION OF N-ACETYL NEURAMINIC ACID
DERIVATIVES**

5 The present invention relates to a process for the preparation of derivatives of N-acetyl neuraminic acid. More particularly the invention relates to a process for the preparation of 5-acetamido-4-amino-2,3,4,5-tetra-deoxy-D-glycero-D-galacto-non-2-enopyranosonic acid (the 4-amino analogue of DANA; also known as 5-(acetylamino)-4-amino-2,6-anhydro-3,4,5-tri-deoxy-D-glycero-D-galacto-non-2-enonic
10 acid).

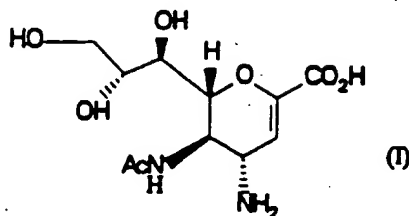
Schreiner *et. al.* Ann. Chem 1991, 129-134 describe the preparation of the 4-amino analogue of DANA from the peracetylated methyl ester of sialic acid (peracetyl NANA methyl ester) by the route shown in Scheme 1.

15 PCT/AU91/00161 (publication no. WO91/16320) describes the preparation of a number of derivatives of 5-acetamido 2,3,5-tri-deoxy-D-glycero-D-galacto-non-2-enopyranosonic acid (2,3-di-deoxy-2,3-di-dehydro-N- acetyl-neuraminic acid; DANA) including the 4-amino analogue of DANA from the peracetylated methyl ester of DANA by a method similar to that of Schreiner *et. al.* with the exception that the peracetylated compound (3a) was reduced prior to deacetylation. The method is
20 shown in Scheme 2.

Our copending application no. PCT/EP92/02904, publication no. WO 93/12105, published 24 June 1993, describes a process for the preparation of 4-amino DANA from the corresponding peracetyl-4-azido analogue by catalytic hydrogenation using gaseous hydrogen.

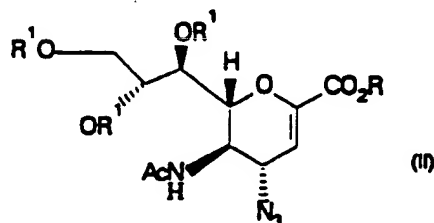
25 We have now found that the yield and purity of 4-amino DANA can be improved by modification of the conversion of peracetyl 4-azido DANA to 4-amino DANA described in PCT/EP92/02904.

The invention thus provides a method for the preparation of the compound of formula (I)



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which comprises catalytic hydrogenolysis of a compound of formula (II)



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(wherein R is H or a C₁₋₄alkyl group and R¹ is H or a hydroxyl protecting group for example an acyl group such as acetyl) in aqueous formic acid followed, where necessary, by hydrolysis.

By aqueous formic acid is meant a solution of formic acid in water or a mixture of water and any compatible organic solvent miscible with water. Preferably the solvent is water. Formic acid is conveniently present in an amount of 1-4 molar equivalents, for example about 2 molar equivalents of the compound of formula (II).

40 The formic acid acts as the source of hydrogen for the hydrogenolysis. It will be appreciated by those skilled in the art that the hydrogenolysis of the compound of formula (I) results in the liberation of nitrogen gas; it is thus advantageous to employ formic acid rather than hydrogen gas as the source of hydrogen.

45 The catalytic reduction may be effected with any suitable catalyst. In one preferred embodiment the catalyst is a palladium catalyst but in particular a poisoned palladium catalyst. A preferred poisoned palladium catalyst is a Pd catalyst

poisoned with lead for example a Lindlar Catalyst. A particularly preferred catalyst comprises 5% palladium on a suitable support such as barium sulphate or, preferably, calcium carbonate, and 3 to 7% lead by weight of catalyst, such as 4 to 6% lead, more preferably 5% lead.

In an alternative preferred embodiment the catalyst is an unpoisoned catalyst, in particular, a palladium catalyst, for example palladium on charcoal.

The reduction is conveniently carried out at 0-50°C, preferably at 20-30°C.

In a preferred aspect of the invention the compound of formula (II) is deprotected, that is to say that R and R¹ are both hydrogen. The compound of formula (II) wherein R and R¹ are both hydrogen may be obtained by hydrolysis of the corresponding compound of formula (II) wherein R is a C₁₋₄ alkyl group and R¹ is a hydroxyl protecting group such as acetyl. The hydrolysis may be effected with any suitable inorganic or organic base. Preferably an organic base such as triethylamine or, particularly, 1,8-diazabicyclo [5.4.0]undec-7-ene (DBU) is employed. Water or a mixture of water and any compatible organic solvent miscible with water is conveniently employed as the solvent. Preferably water is used. The reaction is conveniently carried out at ambient temperature. Conveniently at least 5 molar equivalents of base will be employed; alternatively a catalytic quantity of base may be employed where trans-esterification is used by incorporation of an alcohol, eg methanol, in the solvent mixture.

To facilitate isolation of the compound of formula (I), the pH of the reaction mixture is preferably optimised. Optimal pH for the isolation of the compound of formula (I) is in the range of 3 to 9, preferably 5 to 8, more preferably about 6.5. Adjustment to optimal pH may suitably be effected by addition of an acid, such as an organic acid, for example formic acid, or a base, such as an organic base, for example 1,8-diazabicyclo[5.4.0]undec-7-enem (DBU), as appropriate.

The compound of formula (I) may be isolated by any convenient method known in the art. However, the compound of formula (I) is preferably obtained by crystallisation. By this means 4-amino DANA is readily obtained substantially free of impurities.

Crystallisation can be induced by treating an aqueous solution of 4-amino DANA with an antisolvent, for example *iso*-propanol, at a temperature of from 10-80 °C, for example 25-70°C such as about 60°C.

- 80 The 4-amino analogue of DANA is a potent inhibitor of influenza virus both in vitro and in vivo and is thus useful in the treatment of viral infections such as influenza. (see for example WO91/16320).

- The 4-amino analogue of DANA is also of use as an intermediate in the synthesis of other DANA derivatives which are inhibitors of influenza virus (see for example
85 WO91/16320).

The invention is illustrated by the following non-limiting examples. All temperatures are in °C.

Example 1

- Methyl 5-acetamido-7,8,9-tri-O-acetyl-4-azido-2,3,4,5-tetra-deoxy-D-glycero-D-galacto-non-2-enopyranosonate as its monohydrate, (20g) was suspended in water
90 (40ml) and chilled with stirring to 10°. 1,8-Diazabicyclo[5.4.0]undec-7-ene (31.5ml) was added over 20 minutes. The mixture was then stirred at 20°C for 1.5h, giving a clear solution.

- Lindlar catalyst (1g), then formic acid (3.2ml) were added and the mixture stirred at
95 20° for 16h. Filter aid (1g) was added, then reaction mixture filtered to remove the catalyst. The spent catalyst bed was washed with water (3 x 0.67ml).

The filtrate and washings were combined and formic acid was added till a pH of 6.5 was reached. The resulting solution was heated to 60° and the product was crystallised by adding *iso*-propyl alcohol (400ml) in portions.

- 100 The resulting crystalline slurry was cooled to 5° overnight, then filtered, and the product washed with *iso*-propyl alcohol (2 x 40ml), then dried *in vacuo* at 40° for 16h, to give the 4-amino analogue of DANA (12.25g) as a trihydrate.

N.M.R. (D₂O) 5.62 (1H,d,2); 4.40-4.25(2H,m);

105 4.18 (1H,m); 4.05-3.50 (4H,m); 2.08 (3H,s)

I.R. (Nujol) 3526, 3477, 3388, 3179 (HO,NH);
1675 (CO, amide), 1601cm⁻¹ (CO, CO₂H)

Example 2

110 A solution of Methyl 5-acetamido-7,8,9-tri-O-acetyl-4-azido-2,3,4,5-tetra-deoxy-D-glycero-D-galacto-non-2-enopyranosonate as its monohydrate, (2g) in water (6ml) and methanol (14ml) was treated with triethylamine (1.17ml) and 1,8-diazabicyclo[5.4.0]undec-7-ene (1.89ml). After stirring the resulting solution for 1.2h at 20°, 10% palladium on activated carbon catalyst (0.2g) and formic acid (0.32ml)
115 were added. The mixture was stirred under nitrogen at 20° for 18h, then filter aid (0.2g) added.

The reaction mixture was filtered to remove the catalyst, then the spent catalyst bed was washed with water (2 x 4ml). The filtrate and washings were combined and concentrated to 16ml *in vacuo*. The resulting solution was heated to 60° and the
120 product crystallised by adding *iso*-propyl alcohol (80ml) in portions.

The resulting crystalline slurry was cooled to ambient temperature, then filtered, and the product washed with *iso*-propyl alcohol (2 x 4ml), then dried *in vacuo* at 40°, to give the 4-amino analogue of DANA (0.63g), identical to the product of Example 1.

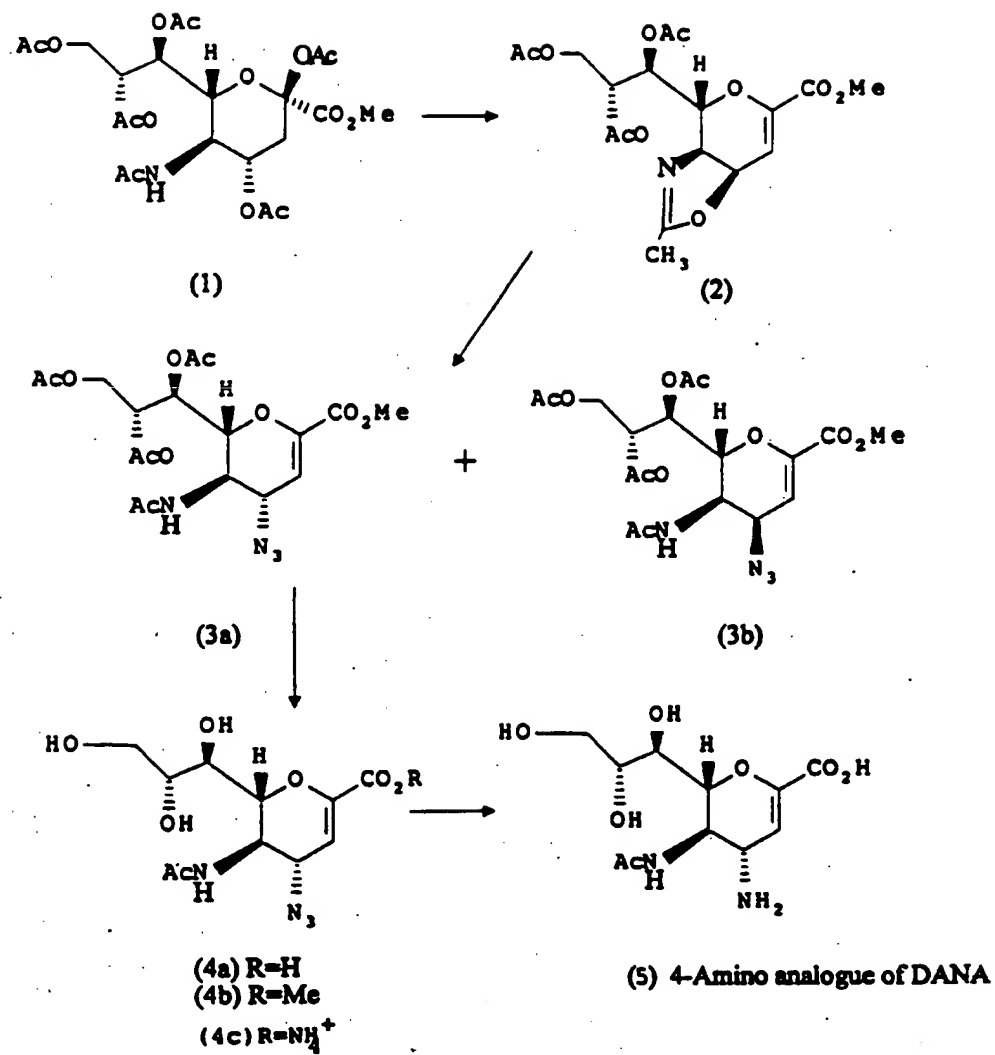
Example 3

125 A solution of Methyl 5-acetamido-7,8,9-tri-O-acetyl-4-azido-2,3,4,5-tetra-deoxy-D-glycero-D-galacto-non-2-enopyranosonate as its monohydrate, (100g) in water (150ml) at about 10° was treated with 1,8-diazabicyclo[5.4.0]undec-7-ene (158ml) and stirred at about 20° for ca. 1.5h, giving a solution. Lindlar catalyst (5g) comprising 5% palladium on calcium carbonate and 5% lead was added, followed by
130 formic acid (15.9ml) whilst the temperature was kept below 30°. The mixture was maintained at 25-30° for approximately 16h. The catalyst was removed by filtration through a prepared filter-bed, which was then washed with water (2x50ml).

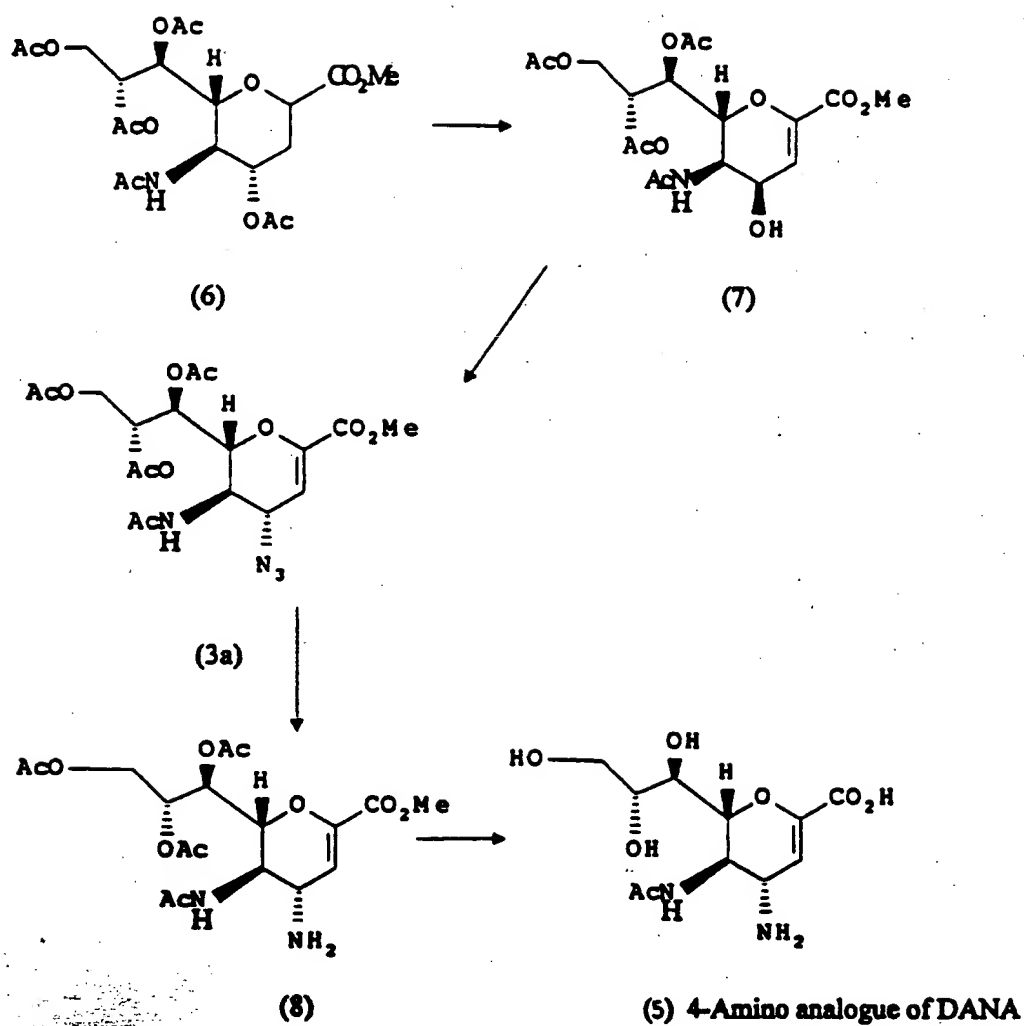
The combined filtrate and washings were adjusted to pH6.5 by addition of formic

135 acid (10ml). The solution was stirred for 30min, then re-acidified to pH6.5 by addition
of a further few drops of formic acid. The solution was warmed to about 60° and
diluted with *isopropanol* (800ml), then allowed to crystallise. The mixture was
reheated to 60° and further diluted with *isopropanol* (1200ml). The resulting
suspension was stirred for approximately 16h, then cooled to about 5°. The solid
140 was isolated by filtration, washed with *isopropanol* (2x200ml) and vacuum dried at
40° to give the 4-amino analogue of DANA (62.4g), identical to the product of
Example 1.

Scheme 1

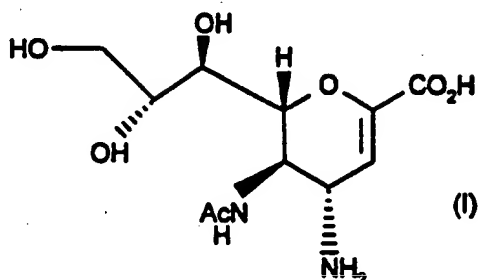


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Scheme 2

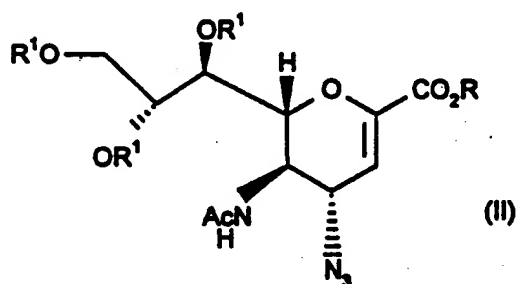
Claims

1. A process for the preparation of a compound of formula (I)



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which comprises catalytic hydrogenolysis of a compound of formula (II)



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wherein R is H or C_{1-4} alkyl and R^1 is H or a hydroxyl protecting group, in aqueous formic acid.

15

2. A process as claimed in Claim 1 wherein the catalyst is a palladium catalyst.
3. A process as claimed in Claim 1 or Claim 2 wherein the catalyst is a poisoned palladium catalyst.
4. A process as claimed in any one of Claims 1 to 3 wherein the catalyst is a palladium catalyst poisoned with lead.
- 20 5. A process as claimed in any one of Claims 1 to 4 wherein the catalyst is a Lindlar catalyst.

6. A process as claimed in any one of Claims 1 to 5 wherein the catalyst comprises 5% palladium on a support and 3 to 7% lead.
7. A process as claimed in Claim 6 wherein the support is calcium carbonate.
8. A process as claimed in Claim 6 or Claim 7 wherein the lead content is 5%.
9. A process as claimed in any one of Claims 1 to 8 wherein the formic acid is present in an amount of 1-4 molar equivalents of the compound of formula (II).
10. A process as claimed in Claim 9 wherein the formic acid is present in an amount of about 2 molar equivalents of the compound of formula (II).
11. A process as claimed in any one of Claims 1 to 10 which is carried out at a temperature of 0 to 50°C.
12. A process as claimed in any one of Claims 1 to 11 wherein in the compound of formula (II) at least one of R and R¹ is not hydrogen and wherein the product of reduction is subsequently hydrolysed.
13. A process as claimed in Claim 12 wherein the hydrolysis is effected in aqueous medium.
14. A process as claimed in Claim 12 or Claim 13 wherein the hydrolysis is effected with a base selected from triethylamine and 1, 8-diazabicyclo [5.4.0] undec - 7 - ene.
15. A process as claimed in any one of Claims 1 to 14 wherein the pH of the reaction mixture is adjusted to within the range of 3 to 9 prior to isolation of the compound of formula (I).
16. A process as claimed in claim 15 wherein the pH is adjusted to about 6.5.

INTERNATIONAL SEARCH REPORT

 Int. Appl. No.
PCT/EP 94/01940
A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 C07D309/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 C07D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO,A,91 16320 (BIOTA) 31 October 1991 cited in the application see page 21 - page 22; claims 16-19	1
P,X	WO,A,93 12105 (GLAXO GROUP) 24 June 1993 see claims 10-20	1-13

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-9116320	31-10-91	AU-A- 7533891	12-12-91
		AU-A- 7759091	11-11-91
		CN-A- 1057260	25-12-91
		EP-A- 0526543	10-02-93
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		QA-A- 9679	15-05-93
WO-A-9312105	24-06-93	AU-B- 3158893	19-07-93